THE MASSACHUSETTS TOXICS USE REDUCTION INSTITUTE

Massachusetts Chemical Fact Sheet

Perchloroethylene (PCE)

Perchloroethylene (PCE) is both a potential carcinogen and teratogen. Dow Chemical, PPG Industries, and Vulcan Materials Company are the only U.S.-based manufacturers of PCE. Massachusetts companies use PCE to degrease metals, dry clean garments, and manufacture specialty products. PCE use in Massachusetts declined dramatically between 1990 and 1996 as businesses adopted safer substitutes.

FACTS

Common Names:	PERC, PCE, Tetrachloroethylene
Chemical formula:	C_2Cl_4
CAS Number:	127-18-4
Vapor Pressure:	14 mm Hg at 20°C
Water Solubility:	Insoluble
Odor:	Sweet smell

Hazards

Acute (Short-Term) Health Effects

- Central nervous system effects — psychophysiological functions such as mood and behavioral changes — have been observed at exposures below 20 parts per million (ppm).
- At exposures of 100 ppm PCE can irritate the eyes, nose, mouth, and throat.
- High level exposure can cause a headache, dizziness, light-headedness, vomiting, nausea, unconsciousness, and kidney dysfunction
- PCE is immediately dangerous to life and health at 150 ppm.

Chronic (Long-Term) Health Effects

- Chronic inhalation of PCE causes neurological effects including headaches and impairment of memory, concentration, and intellectual function.
- Animal studies indicate that PCE may be a carcinogen. Carcinogenic effects have been observed from inhaling concentrations of 200 ppm. Both the International Agency for Research on Cancer (IARC) and the U.S. Environmental Protection Agency (EPA) consider PCE a probable human carcinogen.
- PCE may be a reproductive hazard. Higher rates of menstrual disorders and spontaneous abortions have been documented in workers exposed to PCE. However, laboratory and animal testing has not demonstrated significant reproductive toxicity.
- Chronic exposure may damage the liver and kidneys, and affect the central nervous system. Kidney effects have been documented on rodents from airborne concentrations of 200 ppm.

(For section references, see endnote #1.)

This is one in a series of Massachusetts Chemical Fact Sheets prepared for each of the chemicals in significant use on the Toxics Use Reduction Science Advisory Board's 'more hazardous chemicals' list. For more information on the Chemical Categorization Project, consult TURI Technical Report #47.

Exposure

Worker Health

Facilities using PCE must minimize worker exposure.

- Use PCE in closed systems. If a closed production system is infeasible, facilities need to enclose operations and use local exhaust ventilation. Where the potential for exposures exceed 25 ppm use a Mine Safety and Health Administration/National Institute for Occupational Safety and Health-approved supplied-air respirator with a full facepiece.

- Take precautions to avoid PCE contact with skin and eyes. Workers need to wear solvent-resistant gloves and clothing. If PCE contacts skin, immediately wash the exposed area.

Public Health

Reflecting its ubiquitous use, PCE is often found in ambient air, drinking water, and household products.

- Despite its short residence time in the atmosphere, roughly 130 days, PCE is ubiquitous at low levels in ambient air: 0.16 parts per billion (ppb) in rural and remote areas; 0.79 ppb in urban and suburban areas; and 1.3 ppb in areas near emission sources. Residents living near or in apartments above dry cleaning establishments are particularly susceptible to PCE exposure due to inevitable releases.

- PCE has been found at low levels in drinking water; for example, a 1991 U.S. survey reported an average concentration of 0.75 ppb with a maximum of 69 ppb.[2] Between 1993 and 1995, EPA required water suppliers to determine if PCE was present above the maximum contaminant level (MCL) of 0.5 ppb and to remediate any problems.

- An effective degreaser and cleaning agent, PCE is found in a number of consumer products including auto brake cleaners, suede protectors, water repellents, silicone lubricants, and recently dry-cleaned clothes.

(For section references, see endnote #1.)

Use Nationally and in Massachusetts

Only three corporations manufacture PCE in the U.S.: Dow Chemical, PPG Industries, and Vulcan Materials Company. Louisiana is home to all operating PCE manufacturing facilities. National PCE use falls into four main use categories: 1) dry cleaning and textile processing (37%), 2) intermediate chemical use (37%) in the manufacture of hydrogen-based fluorocarbons (HFCs and HCFCs), 3) metal cleaning (15%), and 4) other uses, including auto brake cleaners, suede protectors, water repellents, and silicone lubricants (12%).[3] In 1996, these end uses consumed 300 million pounds of PCE in the U.S.

In 1996, Massachusetts' facilities used 506,000 pounds of PCE (see Table 1).

- The manufacture of PCE-containing products, including the recycling of PCE, was the primary end-use for PCE in Massachusetts, accounting for 41% of PCE use in 1996 (see Table 2).

- Chemical distributors, first required to report under TURA in 1991, accounted for another 33% of Massachusetts' PCE use.

- Metal degreasers and dry cleaners accounted for the remaining 27% of PCE used in Massachusetts. A

Table 1. Massachusetts Perchloroethylene Data: Inputs and Outputs for1990 and 1996

Input Data -- MA TURA	Inputs (pounds) 1990	1996	Change in Inputs (pounds)	% Change
Manufactured or Processed	646,656	373,201	-273,455	-42%
Otherwise Used	344,737	132,729	-212,008	-61%
Total Inputs	991,393	505,930	-485,463	-49%
Output Data -- MA TURA	**Outputs (pounds) 1990**	**1996**	**Change in Outputs (pounds)**	**% Change**
Byproduct	400,962	94,452	-306,510	-76%
Product	577,651	427,949	-149,702	-26%
Total TURA Outputs	978,613	522,401	-456,212	-47%
Releases and Transfers (R&T) -- EPA	**R&T (pounds) 1990**	**1996**	**Change in Outputs (pounds)**	**% Change**
Environmental Releases	298,518	58,371	-240,147	-80%
Off-site Transfers	14,293	31,304	17,011	119%
Total EPA R&T	312,811	89,675	-223,136	-71%

Sources: MA TURA -- Massachusetts Toxics Use Reduction Act data, 1998; and EPA -- US Environmental Protection Agency, Toxics Release Inventory data, 1998.

significant amount of PCE is also used by dry cleaners in quantities below the TURA reporting threshold of 10,000 pounds.

Table 1 includes two sources of "output" data: MA TURA and U.S. Environmental Protection Agency (EPA), Toxics Release Inventory (TRI) data. The MA TURA database includes all non-product material created by a process line prior to release, on-site treatment, or transfer ("byproduct") and the amount of toxic chemical incorporated into a product ("shipped in or as product"). The U.S. EPA, TRI database includes information on the waste materials generated by a facility after on-site treatment: including releases to air, land, and water ("environmental releases") and transfers off-site for treatment or disposal ("off-site transfers").

Lacking manufacturers of fluorocarbons and having manufacturers that invested in toxics use reduction measures, the use and outputs of PCE declined dramatically in Massachusetts between 1990 and 1996.

- Total MA TURA use or 'inputs' declined almost 50%, even with the entry of 229,000 pounds from industrial sectors added in 1991(chemical distributors and professional services).

- For TURA outputs, byproduct declined dramatically, 76%, from 1990 to 1996 while the amount shipped in product decreased 26%.

- Total TRI releases and transfers declined 71%. The increase in off-site transfers was a result of one facility capturing some of their PCE air emissions and sending them off-site.

Driving the Massachusetts decline in PCE use and outputs were dramatic cuts in metal cleaning (80% decline in use) and chemical products (64% decline in use) due to changing product lines and implementing toxics use reduction techniques.

- PCE reported use for cleaning printing plates was completely eliminated.

- PCE use reported by dry cleaners declined by 47% from 1991 (the first reportable year) to 1996.

Table 2. Massachusetts Perchloroethylene Use by Use Categories for 1990 and 1996

Use Categories [1]	Facility Name	Use (pounds) 1990	1996	% Change
Chemical Products	American Finish & Chemical Company[2]	32,000	0	-100%
	AW Chesterton Co.[3]	19,480	87,728	350%
	General Chemical Corp.[4]	0	63,380	n/a
	Laidlaw Chemical Services Inc.[5]	454,574	40,449	-91%
	Shield Packaging[6]	75,822	16,485	-78%
	Total	581,876	208,042	-64%
Distributors	Ashland Chemical Company	0	10,059	n/a
	Astro Chemicals Inc.	0	42,080	n/a
	Van Waters & Rogers	0	113,085	n/a
	Total	0	165,224	n/a
Metal Cleaning - Degreasing	Chemi Graphic Inc.	36,000	0	-100%
	Dana Corporation Everflex	94,836	48,300	-49%
	Extrusion Technology	25,967	0	-100%
	Feeleys Enameling Company	0	20,400	n/a
	Isotronics Inc.	12,900	0	-100%
	Presmet Corp.	24,093	0	-100%
	Springfield Wire Inc.	17,860	0	-100%
	Total	211,656	68,700	-68%
Metal Cleaning - Printing Plates	Avery Dennison Corporation	56,160	0	-100%
	Dow Industries Inc.	17,000	0	-100%
	Flexographic Printing Plate Co.	19,800	0	-100%
	Rexam Medical Packaging Inc.	17,841	0	-100%
	Westvaco	21,300	0	-100%
	Total	132,101	0	-100%
Dry Cleaning and Textile Processing	Adams Laundry & Dry Cleaning Co. Inc.	0	13,541	n/a
	Standard Uniform Services (#11252)	0	26,533	n/a
	Standard Uniform Services (#137247)	0	23,890	n/a
	Swan Finishing Company Inc.	65,760	0	-100%
	Total	65,760	63,964	-3%
	Grand Total	**991,393**	**505,930**	**-49%**

[1] Use Categories were assigned based on TURA production unit descriptions that were not specifically intended for this use. The final categories do not necessarily represent the manufacturers' descriptions of their use.
[2] American Finish manufactures solvent-based cements.
[3] AW Chesteron uses PCE in the manufacture of maintenance products and for degreasing, with 99% used in products.
[4] General Chemical both manufactures reclaimed solvent products and re-packages PCE.
[5] Laidlaw Chemical Services manufactures mixed organic solvent products.
[6] Shield Packaging uses PCE in the manufacture of aerosol liquid and powder products.
Source: Massachusetts Toxics Use Reduction Act data, 1998.

Alternatives

One alternative for PCE as a degreaser is to redesign the production process to eliminate the need for cleaning. [5] Facilities can redefine cleanliness specifications, eliminate the process step that results in a dirty part or change the nature of the soil to eliminate the need for cleaning (e.g., vanishing machining oils).

When cleaning is necessary, many alternatives to PCE exist as evidenced by the TURA data. The two most popular alternatives to PCE for degreasing are aqueous and semi-aqueous systems. Positive environmental aspects of the aqueous and semi-aqueous alternatives are that workers are not exposed to solvents, less hazardous solid waste is produced and emission control is not necessary. In addition to aqueous and semi-aqueous systems, there are non-chlorinated solvent systems, mechanical cleaning processes (e.g., abrasive blasting) and other emerging cleaning technologies (e.g., laser cleaning).

The Toxics Use Reduction Institute's Surface Cleaning Laboratory assists companies in finding cost effective alternatives to solvent cleaning systems while maintaining product quality. One example of replacement of a PCE vapor degreaser is a Massachusetts metal screw machine products manufacturer that is implementing an aqueous ultrasonic cleaning system for removing various cutting fluids and metal fines.

Typically called "dry cleaning" the process of using PCE to clean garments is not actually dry, rather it involves soaking the clothes in the solvent and then evaporating the solvent from the clothes. PCE has been and is now the most common garment cleaning solvent. However, due to the hazards associated with PCE, safer alternatives for cleaning garments have been developed.

Consumers can reduce the demand for perc-cleaned clothes by purchasing garments that can be laundered at home or by using a dry cleaning establishment that offers soap and water laundering. In the care of a professional, water can be used on many fabrics that are labeled "dry clean only."

The water alternatives to dry cleaning with PCE are multi-process wet cleaning and machine wet cleaning. Multiprocess wet cleaning uses a variety of techniques including steaming, immersion and gentle hand washing in soapy water, hand scrubbing, tumble drying and air drying depending on the type of fabric and stain to be cleaned. Machine wet cleaning is similar to household washing and drying without the intense agitation and tumbling that may harm delicate fabrics. Aqueous processes are competitive with PCE garment cleaning in terms of both costs and quality.

Petroleum solvents can also be used as alternatives to PCE for garment cleaning. These solvents are not drop-in replacements however, requiring equipment and safety modifications due to their flammability.

(For section references, see endnote #4.)

Regulatory Context

The U.S. EPA and Occupational Safety and Health Administration (OSHA) both regulate PCE.[6] Regulations set by EPA include national air standards for dry cleaning and degreasing operations, and drinking water standards.

- On September 23, 1993, the EPA promulgated a National Emission Standard for Hazardous Air

Pollutants (NESHAP) to control PCE emissions from dry cleaning facilities. The NESHAP varies with facility size and includes provisions on pollution control equipment, emissions monitoring, and record-keeping and reporting requirements.

- Under the NESHAP for halogenated solvent cleaners — effective December 1994 — PCE vapor degreasers must meet emission standards based on the maximum achievable control technology (MACT); this includes installing control equipment, complying with an idling emissions limit, installing automated parts handling, and complying with a total emissions limit.
- Under the Safe Drinking Water Act, the MCL for PCE is 5 ppb. The MCL is the maximum permissible level of drinking water contaminant in a public water system.

The OSHA permissible exposure limit (PEL) is 100 ppm (averaged over eight hours) and the maximum exposure level is 200 ppm.

PCE use is also tightly regulated in Europe, especially in Sweden where the goal is a phase-out of all PCE uses by the beginning of the 21st century.

(For section references, see endnote #5.)

Endnotes

[1] The data in the 'Hazard' and 'Exposure' sections were collected from the following sources: Environmental Defense Fund (EDF), 1999, "Chemical Profile for Tetrachloroethylene" (New York: EDF — see webpage: http:/www.scorecard.org/chemical profiles); L.A. Landner, Grimvall, H. HDkansson, O. Sangfors, and E. Walterson, 1995, *Chlorine and Chlorinated Compounds: Survey of Fluxes to and in the Environment, Pools in the Environment and Health and Environmental Risks* (Report No. 5/95) (Solna, Sweden: Swedish National Chemicals Inspectorate); Richard J. Lewis, Sr. (ed.), 1993, *Hazardous Chemicals Desk Reference* (third edition) (New York: Van Nostrand Reinhold); New Jersey Department of Health and Senior Services, 1996, "Hazardous Substance Fact Sheet: Tetrachloroethylene" (Trenton, New Jersey — see webpage: http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm); and U.S. EPA, Office of Air Quality Planning and Standards, 1998, "Tetrachloroethylene" (Washington, D.C.: U.S. EPA — see webpage: http://www.epa.gov/ttn/uatw/hlthef/tet-ethy.html).

[2] USEPA, OAQPS, 1996.

[3] The national chemical use data in this section are from Stanford Research Institute (SRI) International, 1999, *Chemical Economics Handbook*, "C_2 Chlorinated Solvents" (Palo Alto, California: SRI).

[4] The data in the 'Alternatives' section were collected from the following sources: Gary Davis, et al, 1994, *The Product Side of Pollution Prevention: Evaluating the Potential for Safe Substitutes*, prepared for the U.S. EPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio (Knoxville, Tennessee: Center for Clean Products and Clean Technologies); TURI (Toxics Use Reduction Institute) and the Office of Technical Assistance for Toxics Use Reduction, 1997, *Guidebook of Part Cleaning Alternatives* (Lowell, Massachusetts: TURI); and U.S. EPA, 1998, "Cleaner Technologies Substitutes Assessment for Professional Fabric Care Processes." (EPA/744-B-98-001) (Washington, D.C.: U.S. EPA).

[5] The data in the 'Regulatory' section are from the following sources: EDF, 1999 (see endnote #1 for full citations); U.S. EPA, September 23, 1993, "National Perchloroethylene Air Emissions Standards for Dry Cleaning Facilities," Federal Register, 40 CFR Part 63, Subpart M; U.S. EPA, November 15, 1994, "Final Air Toxics Rule for Halogenated Solvent Cleaning Machines" (http://www.epa.gov/reg3artd/enforce/toxics/dsdegrea.html); U.S. EPA, December 2, 1994, "National Emission Standards for Hazardous Air Pollutants," Federal Register, 40 CFR Parts 9 and 63; and U.S. EPA, Office of Water, 1998, "Drinking Water and Health: National Primary Drinking Water Regulations: Consumer Factsheet on: Tetrachloroethylene" (Washington, D.C.: USEPA — see webpage: http://www.epa.gov/OGWDW/dwh/c-voc/tetrachl.html).

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